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Utility led rural electrification in Morocco:

Combining grid extension, mini-grids and solar home systems

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ABSTRACT

Morocco has become known for being an example of a well-performing utility-led rural electrification program, but so far little independent research has scrutinized this extraordinary case. Based on a critical review of the available literature this paper attempts to draw a picture of the evolution of rural electrification in Morocco, the policies and programs that have been implemented, and their institutional, technical and financial dimensions. The review reveals that information available about the success of the programme has almost entirely been provided by the utility ONE, which has strategic and commercial interests in showing its achievements in a favourable light. With this in mind, three main principles are identified as having contributed to the rapid evolution of levels of electrification: i) a clear vision and a continuing political commitment to follow the plan; ii) an institutional framework which brings into action the strength of the utility and of both national and international actors; and iii) a finance model that includes all stakeholders and international financial institutions. However, three factors may have been equally important in achieving these results: i) a level of rural electrification in Morocco that from the outset was far below that in comparable neighbouring countries; ii) a high GDP compared to Sub-Saharan African (SSA) countries; and iii) a high level of urban electrification, which allowed cross-subsidization from urban consumers. So while the Moroccan case is inspiring for SSA countries, we need to be prudent before we relate the rapid increase in electrification to the implementation model alone.

1. INTRODUCTION

Since the beginning of the millennium, rural electrification in Africa has gained an increased interest by national governments and international development organisations. After a period of low international support under the restructuring programmes led by the World Bank in the 1990s, a shift was experienced in the beginning of the millennium indicated by the fact that the World Bank in 2009 recommended that more than US$10 billion per year should be invested in rural electrification in Africa [1]. In continuation of this trend, in 2012, the UN Sustainable Energy For All (SE4All) initiative sat a goal of universal energy access for all by 2030 with the objective to spur economic growth, and support improvements in education, health and gender equality [2], [3]. Africa is the continent with the lowest electrification rates with only 68 % of urban and 26 % of rural population having access to electricity [4] and therefore at present much focus is on how high rates of electrification can achieved be in Africa.

On the African continent, rural electrification has been organized according to two different models, the rural electrification agency model and the utility model. In most African countries, the result of the privatization of the power sector has been to place the responsibility for rural electrification on new rural electrification agencies [5]–[8]. These new agencies are responsible for implementing rural electrification plans, either through support to private enterprises and local cooperatives in providing electricity to rural dwellers, or through a bidding process in which local and international enterprises bid on contracts to provide electricity to larger regional concession areas [9].

In a few countries, such as Ghana, South Africa, Tunisia and Morocco, governments have not established new agencies. Rather, they have continued with a utility-led model in which the utilities are responsible for rural electrification activities, although influenced by new technical, organizational and financial approaches [5], [10]. While the rural electrification agency model and the utility-led model have often been described as two distinct models, they should rather be seen as constituting the two poles of a continuum, on which variations between the two extremes are situated. The utility-led model, in which the utility is fully responsible for rural electrification, is to be found at one pole of the continuum, while the rural electrification model, with rural communities being responsible for their own electricity supply, may be seen as the other pole. Along the whole continuum the utility is still responsible for rural electrification under various conditions, based on the extension of the existing grid to villages located close to the grid. The major differences appear when it comes to dispersed settlements and the electrification of villages located so far from the grid that individual solutions or mini-grids are the least costly option. Further descriptions of the various models can be found in [5], [11]–[13]

In Morocco the utility has been responsible for the entire rural electrification programme, extending the grid to reach more than 95% of the population. Unusually for an African context, they have also provided electricity to dispersed villages comprising about 10% of the villages. These isolated or dispersed settlements have been supplied by Solar Home Systems (SHS)[1] through a fee-for-service model, which is overseen by the utility, but operated and managed by private service companies through ten-year concession contracts.

Recently, organisational models for rural electrification have been assessed in a number of country studies, mostly in Asia and Latin America. The most comprehensive contributions in this regard are the two books edited by Barnes [14] and Bhattacharyya [15]. Bhattacharyya focuses on experience with and opportunities for supplementing existing grid connection with mini-grids and off grid solutions, while Barnes focuses mainly on different organisational models for grid based electrification. Both works conclude that the organisational model *per se* is less important than other more fundamental issues, such as strong government commitment, strong and dedicated institutions responsible for rural electrification, efficient prioritization to avoid political interference in implementation and sustainable financing schemes, including concessional finance and a significant element of cross-subsidization [16], [17].

Turning to Africa, Massé [5] has made a comparison of the utility-led models in Morocco and Tunisia and the rural electrification agency models in Burkina Faso, Congo and Madagascar, where he concludes that the rural electrification agency model has resulted in 'very modest' achievements compared to the utility-led models in Morocco and Tunisia. Besides this contribution the experience of different electrification models led by rural electrification agencies has increasingly been subjected to research [11], [12], [18], [19] [9], but apart from the case of South Africa [10], [20] and Tunisia [21] limited research has addressed the utility-led models in Africa. In filling this research gap, research into rural electrification in Morocco constitutes an interesting case because it is a utility-led model at one pole of the continuum mentioned above that has achieved a very high rate of electrification, including reaching out to isolated and dispersed villages. Morocco has therefore been selected as an example showing which technical, organizational and economic conditions and measures may support or hinder progress in rural electrification using a utility-led model. Within this overall objective, the paper discusses the policy measures, institutional framework, finance mechanisms and technical approaches that have been implemented to achieve the fastest growth rates in rural electrification on the continent.

The paper is organized as follows. Section two describes the methodology used in the review. Section three presents the program's achievements in statistical terms, while section four provides an overview of the policies and programs that have been implemented for rural electrification. Sections five to seven provide detailed accounts of the institutional, technical and financing aspects of the electrification scheme, while section eight critically discusses the main achievements and challenges before continuing to the last concluding section.

2. METHODOLOGY

The paper provides a review of existing academic and grey literature, information obtained from the national utility, the Office National d'Electricité (ONE), and information from web-based journals. Descriptions of the rural electrification programme in Morocco are mainly those formulated by the main stakeholders themselves in various publications and Powerpoint presentations: by ONE [22]–[35], by Temasol [36]–[38], and by the funders [39]. Unfortunately, only limited independent research on the challenges and impacts of the implementation of PERG has been published so far, and in any case, being financed by AFD (one of the funder's of the program) [40]. Other contributions are site-specific [41], [42] or technical [43], [44]. As a result, to a large extent we have to rely on the 'official' narratives of the main stakeholders. Therefore the review has been supplemented by information acquired through informal talks with various stakeholders at the ministerial level, as well as with the co-author's experience gained through her employment in the Moroccan Ministry of Energy and Mines from 1993 to 2005. This 'local' knowledge has to some extent made it possible to triangulate the sources used in the review.

3. EVOLUTION OF RURAL ELECTRIFICATION IN MOROCCO

The rural electrification (RE) rate in Morocco has improved significantly since the middle of the 1990, when the first phase of the Global Rural Electrification Programme [2] (PERG) was implemented. The rural electrification rate increased from 18% in 1995 to 88% ten years later (2006) and reached 98.5% in 2013. This achievement was the result of a shift in institutional, financial and technical approaches to rural electrification, which was initiated with PERG and gradually modified according to need. Overall, centralized electrification was adopted as the main means of increasing access to electricity, while decentralized rural electrification using mainly solar energy was provided to unserved villages with scattered and/or low electricity demand and generally located in remote or uneasily accessible zones. The vast majority, 37,099 villages, have been connected to the grid (2,027,120 households), with a smaller but still significant figure of 3,663 villages being equipped by Solar Home Systems (SHS) (51,559 households).[3] The evolution of electricity access beneficiaries (villages/households) and the RE rate since the implementation of PERG are presented in Table 1.

Table 1: Evolution of Rural Electrification: Grid and Solar Electrified Villages (1995-2013)

Year	No. of villages		No. of households		RE
	Grid	Solar	Grid	Solar	Rate
1995					18
1996	557		72133		22
1997	1601		180426		27
1998	2644	87	286899	1500	32
1999	4294	135	440499	1885	39
2000	6009	237	592082	2861	45
2001	7769	317	703312	4169	50
2002	9725	365	823510	5387	55
2003	12289	946	979489	10457	62
2004	15899	1309	1158175	18779	72
2005	20738	1894	1391843	28312	81
2006	24833	2504	1560982	37489	88
2007	28476	3163	1772241	44719	93
2008	30766	3653	1815047	51509	95.4
2009	32007	3663	1866443	51559	96.5
2010	33150	3663	1906291	51559	96.8
2011	34070	3663	1938747	51559	97.0
2012	35600	3663	1985709	51559	97.9
2013	37099	3663	2027120	51559	98.5

Source: ONE website as of Dec 25, 2011 and June 10, 2014 http://www.one.org.ma/

This increase in Morocco's rate of electrification should be seen in the context of a very low initial electrification rate compared to those of other Maghreb countries. While in 1990 the electrification rate in Morocco was about 14%, it was about 70 % in Tunisia, 80% in Algeria and 84% in Egypt [45]. Also, some years earlier Tunisia experienced a similar impressive increase in electrification rates (from 6 % in 1975 to 88 % in 2000) with an utility led approach [21]. Still the development in Morocco is outstanding compared to most other countries on the African continent. The next section will describe in more detail the policy context that has shaped this evolution.

4. POLICIES AND PROGRAMS

Prior to the PERG, rural electrification in Morocco was implemented through two succeeding phases of the National Programme for Rural Electrification (PNER I: 1982-1986 and PNER II: 1991-2000).[4] PNER I was funded 50% by the government and 50% by local authorities, achieving the electrification of some 287 villages comprising 80,000 rural households. In 1995, four years after its start, PNER II had only electrified 232 villages, mainly because the principle of 100% funding by rural municipalities resulted in a very slow pace [23], [35], [46].

Given this situation, and inspired by several decentralized rural electrification initiatives carried out by various actors, including the Renewable Energy Agency (CDER) and the general directorate for local authorities,[5] in 1996 the government decided to launch a new approach to rural electrification as part of an ambitious national program, the Global Rural Electrification Programme (PERG) [23].

According to some authors [22]–[24], the overall objective of the PERG was the promotion and facilitation of social and economic development, as well as rural empowerment. This reflects the fact that the PERG was launched at a time when, in line with most development actors, the Moroccan government saw rural infrastructure as important in enabling rural development. In this context, rural electrification had a high priority along with the construction of the rural road network (the PNRR program)[6] and rural water supply (the PAGER program).[7]

PERG was based on lessons learned from the previous PNER, which did not progress as planned, due to the shortage of financial resources of local communes. Consequently, ring-fenced funds for rural electrification were set up with contributions from the utility and a levy on electricity sales to alleviate the communes' financial burden for rural electrification.

The promotion of a sense of local ownership of the RE programme was a central element in the PERG approach. This was ensured by means of upfront payments for the consumers, but as we shall see later, the participatory approach also covered planning, decision-making and implementation.

A clear objective and period of implementation were set up for PERG, given the rural populations' high demand for rural electrification and the support of the local authorities. PERG was launched with the objective of achieving a rural electrification rate of 80% by 2010, with a total investment of 15 billion Dh and a yearly average of 1000 villages (100,000 households) to be electrified [23]. This objective was changed midway to a more ambitious rural electrification target of 98% by 2007, because progress proved to be faster than first envisaged [28].

PERG was technology-neutral and based on a least-cost approach. Individual solar SHS were selected in cases where grid connection was not competitive due to the length of the transmission lines required. PERG's cost-efficiency principles also include efficient design and construction for the grid extension (lowering the height of telegraph poles, placing transformers at the tops of poles etc.), as well as good knowledge of the targeted villages (location, distance to the grid, electricity demand, etc.) [23].

In 2006, when the major implementation of the plan had been achieved, ONE initiated a programme (PVER)[8] focusing on socio-economic development in rural areas. PVER focused on the creation and promotion of income-generating activities around the rural electricity grid and on integration into national and regional development projects using electricity for irrigation, cooling and rural tourism. The programme also promoted the use of community services using electricity and tried to ensure that poorer households also acquired access to electricity [34], [47], [48].

The PVER programme was given a high profile, and ONE established a new dedicated office to elaborate and manage the programme at the national level, while the regional or other decentralized offices of the utility managed the programme at the local level in collaboration with regional partners. Local partners included NGOs involved in rural development, micro-finance institutions, universities, financial institutions, local municipalities, international organizations, national and regional development agencies and the ministries in charge of agriculture, tourism, handicrafts, etc. [34], [47].

5. INSTITUTIONAL FRAMEWORK

The main outcome of the power sector reforms in Morocco was the privatization of national power production and power distribution in the major cities. In contrast to many SSA countries, reform of the power sector in Morocco did not lead to the creation of a rural electrification agency. Instead, full responsibility for implementing the PERG (covering both grid- and off-grid rural electrification) was left with the state-owned utility, ONE. The reason for choosing this 'utility model' seems to have been the limited success of rural electrification in the 1970s and 1980s, during which the local authorities were fully responsible for financing rural electrification [23].

ONE is an integrated power company, a national transmission and system operator, a distribution company (especially in rural areas) and a ‘single buyer’ of electricity. It has a 51% market share in final power supply, while municipal and private distribution companies supply the rest.

To coordinate PERG, ONE set up a new, dedicated rural electrification department (directorate) that over time consisted of around hundred staff with experience of the power sector. The directorate was responsible for overall electricity planning, identification of villages, mobilizing villagers, supervision, quality control, Geographic Information Systems (GIS), etc. [23].

It should be emphasized that implementation of PERG is based on a participatory approach, with a significant role being given to local municipalities in terms of approval of zones, identification of households and more generally providing access to local information [23].

Since the launching of PERG, ONE has adopted the principle of the cost efficiency of rural electrification based on competition between private companies. Around sixty enterprises participated in PERG, being responsible for constructions, specific studies and development plans.

Decentralized rural electrification
Off-grid electrification is an alternative option included in the PERG, being targeted at remote villages and dispersed settlements with expensive grid connections. SHS were the main option considered for PERG on grounds of technical and economic feasibility, convenience in use and the high levels of solar radiation throughout the county.

In 1996, when PERG was launched, 150,000 households were identified as having high costs for on-grid electrification. This represented around 10% of households in rural areas and led to Morocco becoming one of the world's most important solar-based electrification schemes at the time [35].

This was a huge challenge for ONE and, based on experience from a pilot project for off-grid electrification, PPER,[9] a main concern was the long-term maintenance of the systems. In order to speed up the process, to ensure a sustainable electricity service and to integrate existing technical and organizational knowledge, ONE decided to outsource the off-grid component to private-sector actors [35]. An international bidding process was established to select enterprises for ten-year concessions, and a first contract to supply 16,000 households with electricity was signed between Temasol[10] and ONE in 2002 [39].

The concession contract set up the conditions for a fee-for-service model, according to which Temasol should install and maintain the installations for a period of ten years. The consumers pay a connection fee, as well as a monthly fee that depends on the size and the year of installation, as further explained in section seven.

In the applied public–private partnership model, the private service provider is in charge of:

- Marketing: identifying potential clients and generating demand.
- Contracting: signing subscription contracts with the consumer on behalf of ONE.
- Installation: buying and installing all PV system components. Installation should be done within fifteen days of the contract with the consumer being signed.
- Maintenance: delivering free of charge after-sale service and renewals during the ten-year warranty period. This includes a clause providing technical assistance within 48 hours of problems arising.
- Revenue collection: collection of the connection fee and the monthly fee during the ten-year concession period.
- Environmental control: maintenance includes changing batteries and recycling used batteries [35], [36].

ONE remains the owner of all installations, and formally the consumer is a customer of the utility. The utility also certifies the PV systems to be installed and conducts quality control of their performance [35], [36], [39].

The local communes are also important partners in the process. Based on the overall planning described below, agreements are signed between ONE and the local communes, making it clear which rural villages (*douars*) are eligible for grid-connected electricity and for individual solutions. It is expected that the rural municipalities will also help in providing a conducive environment for the agents from the service provider to promote the SHS [40].

Temasol operates through fourteen local branches and employs a total of 78 people [36]. While sales, installation and maintenance are the responsibility of staff at the local branches, Temasol has applied an organizational model, with a high level of control by the headquarters in Rabat. The employees of the local branches attend the weekly local markets to market the SHS, signing contracts with clients and requesting the SHS from headquarters. Systems are sent to the local branch and installed by the staff there, who also inform and train the client in the use of the system. With regard to maintenance, each branch receives from headquarters a list of customers to visit and fees to be collected, and they also receive the necessary spare parts, such as bulbs, batteries and controllers [40].

Besides Temasol, four other concessionaires were involved in providing SHS in Morocco, and although the operation of these concessions is not described in the literature, in theory they followed the same implementation modalities as Temasol. In 2005, according to [49] and confirmed by [26]–[28] concession contracts were signed for 105,000 SHS out of the 150,000 SHS envisaged when PERG was launched back in 1997. The concessions were acquired by different local branches of international companies, as shown in Table 2. Temasol was responsible in total for 59,000 installations, Isofoton for 34,000, Sunlight Power Maroc for 8,000 and Apex BP Solar for 4,000.

Table2. Concessions for SHS

PERG project number	Company	SHS
Project no. 1	Temasol	16,000
Project no. 2	Sunlight Power Maroc	8,000
	Apex BP Solar	4,000
Project no. 3	Temasol	37,000
Project no. 4	Isofoton	34,000
	Temasol	6,000
Total concessions		105,000

Source: [49]

As already shown in section three, a total of 51,559 systems were actually installed by 2013. This constitutes about 32% of what was first planned and only about 50% of the targets in the concessions. Temasol apparently had 23,000 systems functioning in 2011 out of a total of 26,000 systems installed [36], , while Isofoton had installed about 13,000 systems by 2011 [50]. No official statistical information has been available on how many kits were installed by each of the concessionaires.

6. TECHNICAL AND PLANNING ASPECTS

Rural electrification has been carried out using an integrated approach, including grid and off-grid options, under a single global program, namely PERG, to ensure fairness in terms of advantages for the beneficiary and coherence in the electrification process. The assessment of needs in relation to rural electrification was undertaken throughout the country at the start of PERG using a survey campaign that aimed to cover 36,000 villages. The utility technicians visited the villages to enquire about their geographical locations and delineations, populations, number of households and businesses, electricity needs, existing and necessary infrastructures, existing social amenities, etc. [24].

In order to manage the large amount of collected information on rural households and villages, as well as economic, social and electricity infrastructures, the utility used a Geographical Information System (GIS). The GIS was utilized for the rural electrification planning and costing, the spatial positioning of the villages throughout the country and in evaluating progress with PERG [35]. Grid extensions were first planned based on the principle of spatial optimization, the objective being to maximize village connections within the overall budget. As this approach resulted in unequal regional coverage, provisions to ensure a regional spread were later included in the grid optimization.

With the objective of reducing costs, new concepts and new technical solutions were introduced in PERG. One example was to lower the height of the low voltage (LV) poles from 10.5 to 9m, and later to 8m. This led to cost reductions of 20%. Another example was to place the transformers at the top of the poles, which led to more than 35% of cost reductions for transformers [23].

The programme was based on the principle of least-cost optimization, which implied that areas included in the electrification scheme were selected according to the lowest grid extension cost. In the first phase, only households with extension costs lower than 10,000 Dh/household (around € 890)[11] were included. This limit was later changed to 14,000 Dh (2002) and again to 20,000 Dh (2004), ending up at 27,000 Dh/household (€ 2,400) in the last phase starting in 2006. Customers for whom grid extension costs exceeded 27000 Dh were 'left with' individual solar home systems or mini-grids [35].

While different options for electricity supply to local mini-grids, such as PV, micro-hydro, wind mills, diesel engines and hybrid systems, could in principle be included under the decentralized rural electrification program, in practice the vast majority turned out to be individual SHS. By 2006, only two villages had been equipped with a wind-diesel system, two were being powered by micro-hydro and twelve were being supplied by diesel generators [35], while by 2009 the villages connected to micro-hydro had increased to 63 [51].

For individual consumers in villages and dispersed settlements, three technical options were offered:

- 50 W_p PV capacity: to fulfil the domestic lighting needs of the household.
- 75 W_p and 100 W_p PV capacity: to meet lighting and audio-visual needs.
- 200 W_p PV capacity: in addition to lighting and audio-visual, this capacity provides a refrigeration service.

Besides being a least-cost option, SHSs also avoid use of fossil fuels, thus reducing greenhouse gas emissions. In 1995 the SHS programme was therefore proposed for funding under the Clean Development Mechanism and was registered as one of the first programmatic CDM projects [31], [52].

7. FINANCIAL ASPECTS

The general financial model for rural electrification in Morocco is based on the sharing of responsibilities between the consumers, the municipalities and the utility [23], [51].

The consumer has two options:

- 2500 Dh(€ 220) per household upon connection; or
- 40 Dh (€ 3.6) per month over seven years.

Other partners can provide support to the households' electrification, such as NGOs, regional organizations, etc.

Local municipalities have two options:

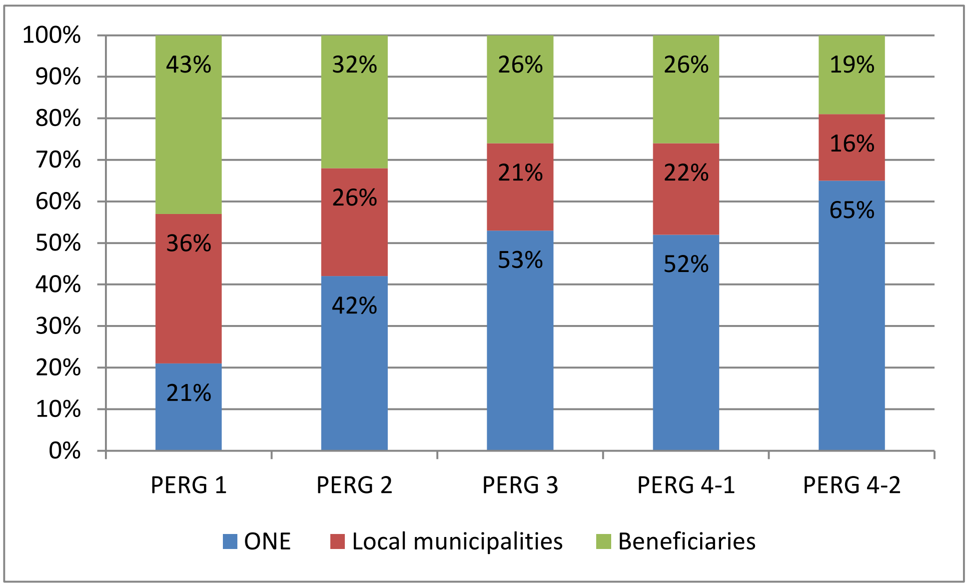
- 2085 Dh (€ 185) at the start-up of electricity supply; or
- 500 Dh (€ 44) per year for each household over five years.

The utility provides the rest.

By 2009, consumers had provided about 25% of the total investment, municipalities about 20% and the utility about 55%. The financial resources of the municipalities came from their Value Added Tax (VAT) allocation, as well as support from the ministry budget and the Municipal Development Fund. The resources of the utility came from a solidarity tax, comprising 2.25 % of on-grid sales, from concessionary loans and from equity.

As mentioned above the delimitation between grid connection and off-grid connection was gradually changed from 10,000 Dh/household at the launch of the PERG to 14,000 Dh in 2002 and to 27,000 Dh in 2006. These changes increased the cost of grid connection significantly [51]. As the amounts paid by consumers and municipalities were fixed, the share of the investment paid by ONE increased over time, as shown in Figure 1.

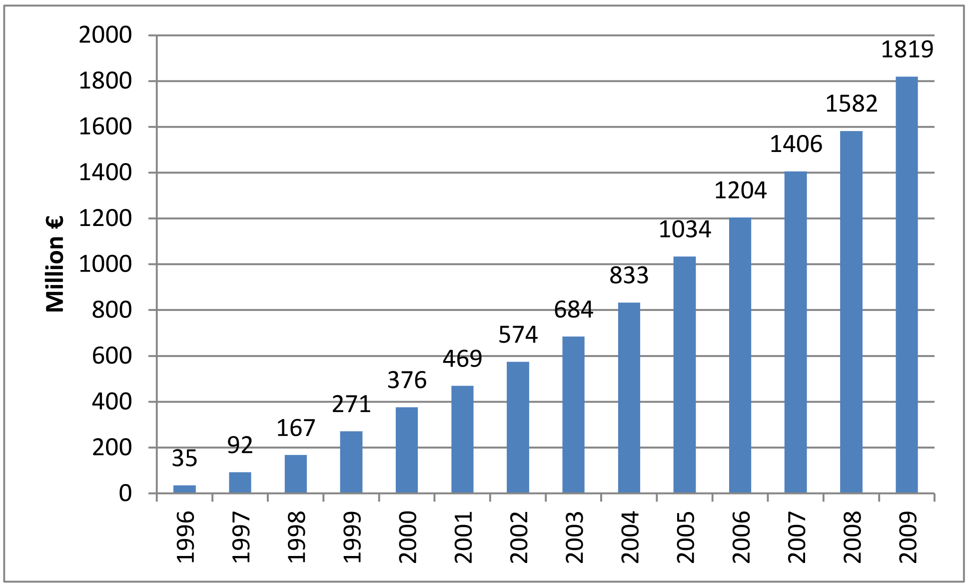
Figure 1. Distribution of costs for grid connections



Source: Adapted from [51]

The total cost of PERG by 2009, when more than 90% of PERG had been implemented, amounts to about € 1800 Million. The increasing cost per household over time is illustrated in the non-linear curve showing accumulated investments in Figure 2 [51].

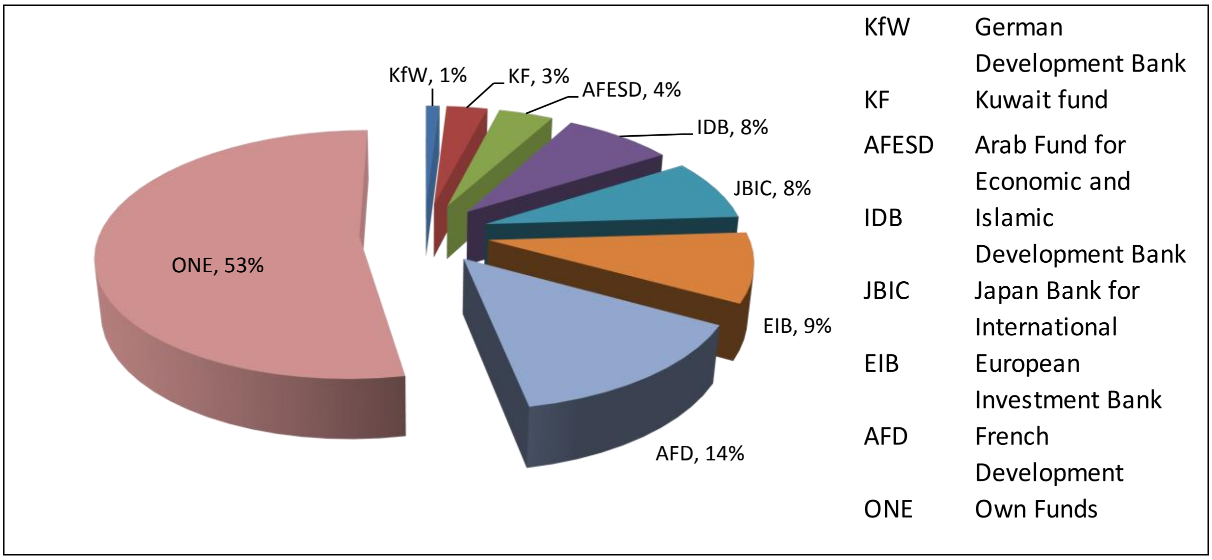
Figure 2: Accumulated budget (Million €): 1996-2009



Source: Adapted from [51]

ONE and the Moroccan government were efficient in attracting donor financing to PERG. Several financial institutions have contributed to PERG through its four implementation phases, mainly by way of concessional loans. This includes international development agencies, international banks and development funds. As shown in Figure 3, by 2008 international donors were responsible for 47% of ONEs share of the RE budget, the remaining 53% being provided by ONE [51].

Figure 3: Financial contributions from international development banks



Source: Adapted from [51]

Besides the contributions shown in Figure 3, the decentralized element of rural electrification has benefited from a USD 6.5 Million grant from KfW and a USD 1.5 Million grant from the French GEF (FGEF) to the first PPP contract implemented by Temasol [37], [39], [53].

Off-grid financial approach

The initial fees and the connection fees for the different systems in Phases 1, 2 and 3 of the Temasol concessions are shown in Table 3 below.

Table 3: Fees for different SHS solutions

Concession phase	Capacity	Electricity services provided	Initial connection fee	Monthly fee
1st phase (16 000 SHS)	50 W_p	4 lamps+ 12V socket	€ 60(700 Dh)	€ 6 (65 Dh)
	75 W_p	6 lamps+ 12V socket	€ 160 (1800 Dh)	€ 8.5 (96 Dh)
	100 W_p	8 lamps+ 12V socket	€ 280 (3100 Dh)	€ 11.5 (129 Dh)
2nd & third phase, (42500 SHS)	75 W_p	4 lamps+ 12V socket	€ 80 (900 Dh)	€ 6(65 Dh)
	200 W_p	4 lamps+ 12V socket + fridge	€ 360 (4000 Dh)	€ 13.5 (150 Dh)

Source: [36]

The way the fees were set was in principle related to rural dwellers' ability to pay, but according to [40] consumers found the 200 W_p system too expensive, and consequently more than 90% chose the 50 and 75 W_p systems, which did not allow them to power a refrigerator.

The subsidy covering 90% of the total equipment costs is paid by ONE to Temasol according to the contract. The remaining 10% is covered by the initial connection fee. This means that Temasol has full cost recovery for its investment, while the monthly fee is designed to cover all costs of service and maintenance, including renewing batteries [40].

8. DISCUSSION

Even though the utility model adopted in Morocco has led to remarkable achievements in terms of levels of electrification, there have also been significant challenges in implementing the program. This section will discuss some of the achievements and further discuss the strength of the technical, institutional and financial models.

Electrification rate versus coverage rate

As discussed in [54], there is no common agreement on the definition of electrification rates. The IEA, which has collected data on electrification rates since 2002, defines them as 'the number of people with access as a percentage of the whole population', while access at the household level is defined as 'the number of people who have electricity in their homes' [55]. Others define electrification rates as 'coverage rates', which means 'percentage of the population living in areas where the service is available' [56].[12] This implies that, if all villages in a region are connected to the grid, then the electrification rate would be 100% for that region, while in practice only a part of the households in each village would be connected.

There is match between the statistics in this paper, which come from official ONE documents, and the IEA database [57], so IEA has apparently accepted the ONE data. However, in the view of the authors it is most likely that the electrification rates provided by ONE are based on 'coverage rates' rather than on actual connections. This is based on the suspicion that it is not likely that more than

95% of villagers would actually connect to the grid in newly electrified villages, and it is supported by the fact that ONE operates with two concepts, an electrification rate and a subscription rate. In the ONE activity report from 2012 it is stated that the rural electrification rate is 98%, while the PERG subscription rate is 90.1% [25]. Similarly , in [34] it is noted that the subscription rate of traditional craft workshops is about 66%.

If this 'hypothesis' is correct, the achievement in terms of electrification level is high, but lower than the 98% claimed by ONE, as shown in section three. A best guess would be that the rural electrification rate according to the IEA definition would be the electrification rate times the subscription rate, or about 89%, but even that might be substantially lower.

Grid versus off-grid electrification

Besides the high electrification rate, the combination of grid and off-grid electrification is the most remarkable in the Moroccan case. In contrast to South Africa, where a similar concession scheme was carried out in the period from 1999 to 2006 [20], [58], the achievements have almost universally been pronounced a success [33], [36], [40].

The goal set for the off-grid option at the outset and as late as 2002 was 150,000 PV systems [26], but only 51,559 systems were actually installed. This is about one third of the original goal, and while it still covers about 10% of the villages, it only constitutes about 2.5% of total connections achieved within the period of PERG. The literature does not provide much explanation as to why only 105,000 of the estimated 150,000 SHS were actually tendered, and more interestingly there are few signs of why only 51,559 of the tendered 105,000 were actually implemented.[13]

While the documents and presentations by stakeholders do not provide indications of why the grid was expanded beyond what was first planned, the most obvious reason is that consumers put political pressure on ONE because (as has been described in South Africa [20], [58]) they saw the SHS as a second-best option, being more expensive and not providing the same services as grid-connection [34], [40]. This explanation is supported by the fact that, already in 2010, ONE started a grid extension programme, the aim of which was to 'respond to the needs of the population, which wants a grid connection instead of SHS, and therefore again to electrify villages which were not in the programme due to their remoteness and the consequently high cost of grid connection at the time' [19] p. 17.

The reason why only 51,559 SHS were actually installed in the concession areas, covering 105,000 homes, might be that the grid was extended beyond what was first planned, but also, and maybe most importantly, because not all households in remote rural areas were actually able to or willing to pay the connection fee and the monthly fee for electricity.

In sum, therefore, while the achievements of the SHS programme in Morocco were remarkable at the time, it only contributed 2.5% of the new connections under the rural electrification program. Moreover, as ONE started a programme to provide grid-connected electricity to villages with SHS, off-grid connection has apparently changed status from a final solution to a solution filling out the gap in the transition to grid-connected electricity.

At the international level, the achievement of having installed 51,559 systems in Morocco is a relative success compared to the concession programme in South Africa, where the goal was 300,000, but where only about 20-30,000 systems were installed [20], [58]. On the other hand, the achievements are relatively small compared to Kenya, where about 400,000 systems have been installed through a facilitated market approach [59].

Grid versus mini-grids

Mini-grids were from the beginning supposed to be an integrated part of the solution [35], and projects for mini-grids supplied by mini-hydro, diesel and hybrids between diesel, solar and wind were initiated in 2002-2004 [26], [27]. However, at the end mini-grids and the experimental technical and organisational solutions seemed to have been supplanted by ONE's grid-connection approach. According to [43], in a number of villages there were small, community-based diesel generators delivering electricity to villagers for a few hours a day, and besides this, various NGO-financed projects were providing electricity through mini-grids. [43] and [41] both describe projects being financed by NGO cooperation in areas which were not included in grid connection by the PERG master plan. These small systems seem to a large extent to have disappeared, as the grid was extended further than expected, ultimately providing these localities with grid electricity from ONE. This illustrates, as discussed above, that in some cases the grid has been extended far beyond the initial plans, but also that, in spite of firm rules, grid connection was in practice part of a political negotiation, as in the case of the *Vallée de l'Ouneine* [41].

Transparency versus rural development

The transparency of the criteria for selecting which villages should be electrified has often been highlighted as one of the positive factors in the achievements of PERG in Morocco [33]. During the conception of the programme the priority was given to the villages with low costs of electrification. This was a technocratic approach, based on a rational technical and financial logic, which was manageable and which could be used by ONE to reduce political interference in the selection of villages to be electrified, as mentioned above.[14] However, this left little consideration for the development dimension at the village and community levels, and it was also contrary to approaches where 'poles of development' were seen to be an equal important parameter for the selection of villages for rural electrification [60].

It was only after completion of a comprehensive impact assessment in 2006 [34] that, by launching PVER, ONE significantly increased its emphasis on the development dimension of rural electrification – not so much in the selection process, but rather through support to income-generating activities, integration with national and regional development projects, and the promotion of community services using electricity [31].

This change in approach over time illustrates that, in line with rural electrification schemes in other countries [1], ONE has changed its technocratic approach in favour of a more development-oriented process regarding rural electrification, but also that it has been able to commission impact assessments, as well as acting on their recommendations.

Integrated development vs. separation or uncoordinated integration

In a recent paper, Urpelainen [3] describes three possible models for integration of grid and off-grid electrification: i) The separation model, where government allocates resources to grid connection and a different set of policy makers focuses on areas not covered by grid connection, ii) the uncoordinated integration model in which grid extension and off-grid electrification are both pursued in an uncoordinated manner, and hence generating competition between the two strategies and iii) the integrated development according to which dedicated institutional structures are responsible for implementing where most appropriate. The utility-led model, where ONE has the overall planning responsibility, the conditions are fulfilled for ensuring an 'integrated development', and this seems also to a great extent to have been the result. However, based on the review, and the fact that mini-grids and off-grid solutions became less widespread than planned, may indicate that consumers' choices and political interference drew the activities slightly towards more expensive grid-connections, in accordance with the wishes from the constituencies.

National versus international expertise and finance
With respect to the utilization of available technical and economic expertise, the Moroccan model seems to have integrated the best of two worlds by benefitting from the available expertise acquired by ONE in planning, implementing and operating grid-based solutions, while new technology in terms of SHS and new management models, sales and service delivery to private consumers have been outsourced to companies with strong international ties to technical and organizational knowledge of SHS, as well as involvement in the production of solar panels.

On the finance side, the approach of sharing the economic responsibility between different parties seems to have been instrumental in achieving the speed of implementation, as well as for long-term sustainability. This is the case on the national level, where the shared economic responsibility between the consumers, the municipalities and the utility was important in the investment phase, and seems to have ensured ownership and fruitful collaboration between the parties, but also at the international level, where ONE and the government, in spite of Morocco being a lower middle income country (according to DAC's classification),[15] managed to get up to 47% of the investment in rural electrification pre-financed through concessional loans.

Compared to how rural electrification schemes have been financed in other countries, it is also important to understand that Morocco's relatively high urban electrification rate made it possible for ONE itself to finance a substantial part through a 2.25% cross subsidy from urban consumers. This observation contributes to the hypothesis put forward by [13] that rapid increases in rural electrification levels are strongly linked to high urban electrification levels, as in South Africa and Ghana, and to the level of GDP [61]. This calls for prudence in attributing too much importance to the implementation model alone.

9. CONCLUSION

Morocco has experienced the most radical increase in rural electrification on the African continent, and although electrification levels in Morocco seems to be calculated in terms of villages connected rather than households connected, the achievement is still extraordinary compared to the experience of other African countries. A unique feature of the Moroccan model is the provision of isolated villages and dispersed settlements with SHS through a concession-based fee-for-service model. However, in spite of the apparently successful implementation of the fee-for-service model, only about one third of the households envisaged have actually been electrified. The off-grid part therefore only contributed 2.5% of the connections in the whole program. This low implementation rate seems to be caused by the low level of acceptance of SHS compared to grid connection, as has also been seen in other African countries.

The main principles that have led to this rapid evolution in electricity levels can in be summarized in three points: i) a clear vision established through the development of a master plan, and a continuing political commitment to follow the plan based on transparent procedures; ii) an institutional framework that exploits the strength of the utility and of national and international actors, as well as paying attention to rural dwellers' low ability to pay; and iii) a finance model bringing together consumers, municipalities and the utility, thus ensuring ownership and collaboration between the main stakeholders at the national level, supplemented by a high degree of international donor funding in terms of mainly concessional loans. These elements are much in line with what Massé [5] found in his collection of African experience and what Barnes [16] and Bhattacharyya [17] identified on a more global level.

The Moroccan case demonstrates that the utility-led model, which was used with success in Tunisia, but discarded by the development community in the 1990s, can perform much better than has been the case in most SSA countries which have applied the alternative rural electrification agency model. However, as already pointed out above, Morocco started out with a rural electrification level which was far below those of its comparable neighbouring countries. It had – and seized – the opportunity to exploit a high level of cross-subsidization from urban consumers, and it had an economic development level measured in GDP which went far beyond that of most SSA countries. As noted above, and in line with [5], [16], [17] we therefore call for prudence not to relate the rapid increase in electrification to the implementation model alone.

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Notes

[1] The PV Solar Home System consists of solar panel(s), a charge controller, battery(s), cables and lamps.
[2] Referred to as PERG: Programme d'Electrification Rurale Globale.
[3] ONE website as of Dec 25, 2011 and June 2014 http://www.one.org.ma/
[4] Referred to as PNER: Programme National d'Electrification Rurale.
[5] La Direction Générale des Collectivités Locales is a directorate under the Ministry of Interior.
[6] Programme National des Routes Rurales (PNRR-1), initiated in 1995.
[7] Programme d'Approvisionnement Groupé en Eau Potable des Populations Rurales (PAGER), initiated in 1995.
[8] Programme de Valorisation de l'Electrification Rurale, or PVER.
[9] Programme de Pré-Électrification Rurale (PPER), which was implemented in 1990-2000 in parallel with PNER II [23].
[10] Temasol was a subsidiary of EDF, TOTAL and TENESOL, the latter itself a subsidiary of EDF and TOTAL. By July 2008, Temasol became fully owned by TENESOL, apparently now fully owned by TOTAL [36], [40].
[11] The Moroccan dirham is abbreviated as Dh in this paper. This is equivalent to MAD. The conversion rate fluctuated in the period from 1995-2005, so for consistency a conversion rate of 1€=11.25 Dh is used throughout the paper. This rate corresponds to the rate used by [36], and is close to the rate on 26.09.14 (1 €=11.05).
[12] The ECOWAS white paper uses the following definitions: *Penetration rate:* For a given area, % of the population connected to the service. *Coverage rate:* % of the population living in areas where the service is available. *Access rate:* % of the considered population which is *effectively* connected to the considered service
[13] It is worth mentioning that there is considerable variation in the figures presented in various documents. This seems mainly to be due to confusion between the number of people and the number of households having access to SHS electricity. For example, Allali (2011) mentions that 106,200 customers were connected by Temasol, apparently being 'people in connected' households rather than SHS installations.
[14] For political interference in rural electrification programmes, see e.g. [62].
[15] See DAC's list of overseas development assistance at http://www.oecd.org/dac/stats/DAC%20List%20used%20for%202011%20flows.pdf